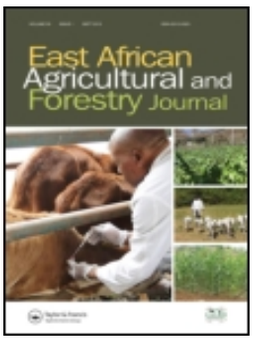

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EFFECTS OF CONCENTRATING RESISTANCE TO NORTHERN LEAF BLIGHT OF MAIZE ON AGRONOMIC TRAITS

H.F. Ojulong, E. Adipala and P.R. Rubaihayo, Makerere University, Department of Crop Science, P.O. Box 7062, Kampala, Uganda

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Lack of appropriate maize varieties in Uganda has been cited as one of the major factors limiting the production of this crop in the country. Thirty-five per cent of the maize grown in the country comprises improved open-pollinated varieties; 60% comprises unimproved open-pollinated varieties which have resulted from planting many generations of the formally improved open-pollinated varieties (Baguma, 1992). This, coupled with the introduction of susceptible cultivars from Centro International de Majeramiento de Maizy Trigo, Mexico (CIMMYT) led to an outbreak of northern leaf blight (NLB) in 1988.

Recurrent selection in two or three cycles improves the resistance of pupulations against insects and diseases (Hughes and Hooker, 1971; Ceballos *et al,*. 1991); agronomic traits like ear and plant heights and days to silking (Paterniani, 1967; Patil *et al.*, 1969; Alvaro and Crane, 1972), and yield (Douglas *et al.*, 1961; Burton *et al.*, 1971; Moll and Stuber, 1971). An important aspect in any recurrent selection programme is the changes that occur for agronomic characters other than the one involved directly in selection. Significant genetic associations have been found between NLB and maturity and NLB and yield, while persistent but non-significant associations have been reported between NLB and plant and ear heights. Ceballos *et al.* (1991) reported yield genetic gains of 6.0 and 3.2% for early and intermediate populations respectively when breeding for resistance to NLB. He also reported significant regression coefficients of 0.63 and 0.53 respectively between NLB and days to 50% silking. Associations have also been reported between days to silking and ear height, plant height and days to silking and ear height and plant height. Selecting for early silk emergency has been effective for developing an early-flowering variety with lower ear placement while days to silking and yield have been noted to have a low positive correlation (Lindsey *et al.*, 1962). A positive correlation exists between yield and ear height. Alvaro and Crane (1972) reported a reduction of 16.4 kg/ha in yield per cm reduction in ear height.

Following the outbreak of NLB in 1988, a recurrent selection programme was started to concentrate resistance to susceptible maize cultivars. The main focus of the programme was to select for resistance to NLB with yield and other traits relegated to secondary priority. The objectives of this study were to: a) concentrate resistance genes to NLB into susceptible maize cultivars, and b) measure associated changes for other agronomic changes especially yield and height.

MATERIALS AND METHODS

The experiments were conducted in the field at Makerere University Agricultural Research Institute, Kabanyolo (MUARIK), Uganda. During the first rains of 1992, seven locally grown cultivars described by Adipala *et al.* (1993b) were crossed with a resistant cultivar, Babungo 3. The resulting F1s were grown together with the parents during the next season for evaluation. Genotypes were planted ear-to-row in a completely randomised block design and replicated three times. Each row consisted of 12 to 15 plants and a plant stand (one plant per hill) was maintained at a spacing of 0.75 by 0.30 m. Because of differences in maturation periods, planting was staggered among varieties and replicates. To ensure heavy and uniform infection, the plants were artificially inoculated twice, at growth stages (GS) 6 and 7 (Adipala *et al.* (1993b).

Lesion length and flag and ear heights measurements (cm) were taken once, at GS 9.3. Twenty clearly expressed lesions per line were measured longitudinally for lesion length. Ear and flag heights were obtained by measuring the distance from the ground to the node where the first well-formed ear was placed and from the ground to where the sheath of the flag leaf spreads. Yield data were obtained at physiological maturity by picking 10 cobs per line, hand-shelling and weighing.

Analysis of variance was performed for all the indices. Data on percentage leaf area affected (PLAA) were used to calculate area under disease progress curve (AUDPC) (Camphell and Madden, 1990). The percentage genetic gains were calculated using the formula:

$$\frac{O\text{-}P \times 100}{P}$$

Where O and P are the performance of the offspring and that of the parents, respectively, (Falconer, 1981).

RESULTS

Varieties showed variability in all aspects considered. Date of planting had a great effect especially on disease severity, which in turn affected agronomic characters. Replicates planted late were more affected than those planted early, especially in the case of susceptible varieties.

There was a significant variation in PLAA among varieties. Variety EV8429-SR had the highest (57. 3%) while Variety Across X Babungo had the lowest (7.6%) PLAA (Table I). All crosses had PLAAs that were lower than that of the donor parent except the cross between H99 x Babungo, which was supposed to have chlorotic resistance (Adipala, pers com.). A high average genetic gain of -22.7% was obtained for PLAA. This value is close to the range obtained by Ceballos *et al.* (1991) of -16.5 to -21.5 per cycle. Crosses with susceptible recipient parents had the highest gains (-41.4 for EV8349-SR and 41.3 for EV8429-SR - 41.3) while the reverse was true for resistant recipient parents. Area under disease progress curve, lesion numbers and lesion length followed the same trend. Increase in resistance resulted in an average reduction of 1.8 days per genotype on number of days to 50% silking (Tables I and II). The greatest reduction (highest negative genetic gains) was on crosses with susceptible recipient parents while the cross with a resistant recipient parent (EV8342-SR) had an increase of 1.4 days (Table I). This indicates a positive correlation between disease resistance and days to silking as again shown by correlation values of 0.42, 0.43, 0.23 and 0.11 for AUDPC, PLAA, lesion number and lesion length respectively.

Flag and ear heights on average increased by 7.8 and 8.5 cm respectively (Tables II and III). The highest increases were observed in crosses with susceptible recipient parents. These parameters decreased or had very low increases in crosses with resistant parents. They exhibited high negative correlation values with disease indices (Table III). High negative correlations of -0.59, -0.60 and -0.52 were obtained between yield and AUDPC, PLAA and lesion numbers respectively. An average increase of 280.8 kg/ha in yield was obtained (Table II), giving a 11.25-kg/ha increase per 1% decrease in disease severity (PLAA). Associations between agronomic traits were also reported. Days to 50% silking was positively correlated with yield, flag height and ear height, while yield was positively correlated with flag and ear heights.

DISCUSSION

Resistance present in the cultivars studied is expressed primarily as lower PLAA, severity numbers and sometimes lesion length (Hughes and Hooker, 1971; Adipala *et al.*, 1993b). Increase in resistance among F_1s led to negative genetic gains. The high genetic gains demonstrate the high heritability of NLB and effectiveness of the programme in incorporating resistance in susceptible maize cultivars and indicate that the cultivars have a low level of resistance. The negative gains for the disease indices confirm earlier findings by Adipala *et al.* (1993b) that the type of resistance present is rate reducing (Nelson, 1976).

TABLE I - MEAN VALUES OF THE DIFFERENT VARIABLES ASSESSED ON THE DIFFERENT PARENTAL AND F_1 POPULATIONS GROWTH IN KABANYOLO, UGANDA DURING THE SECOND RAINS OF 1992

	Days to 50% silking	AUDPC[a]	PLAA[b]	Lesion numbers	Lesion length	Flag height	Ear height	Yield (kg/ha)
Parents								
KWCA-SR	70.7	37.8	48.2	5.3	9.9	176.3	83.2	3866.7
EV3349-SR	61.7	37.4	51.6	5.9	10.8	141.2	60.8	4014.7
EV8429-SR	61.0	45.9	57.3	7.1	11.4	164.5	72.5	3511.3
Across	58.7	21.3	25.7	4.3	11.0	201.7	102.7	4948.0
Gusau	58.0	21.7	24.3	4.6	10.8	173.5	78.5	5481.7
EV8342-SR	58.3	11.0	11.8	2.2	10.7	177.5	75.5	5955.7
Jos	60.7	30.3	39.9	4.9	11.7	153.0	56.2	4081.3
Babungo	58.7	11.6	12.2	2.0	9.4	170.3	87.5	4192.3
Mean	61.6	27.1	33.9	4.6	10.7	170.9	77.1	406.4
Crosses								
KWCA-SR_N								
Babungo	67.7	8.3	8.5	1.1	12.4	182.3	94.2	5036.7
EV8349-SR_N								
Babungo	58.0	10.1	10.2	2.5	12.3	170.5	88.0	5778.0
EV8429-SR_N								
Babungo	60.7	12.6	16.0	3.2	9.4	168.8	80.3	4770.3
$Across_N$								
Babungo	56.7	8.3	7.6	2.0	11.4	192.2	100.0	4770.3
$Gusau_N$								
Babungo	57.3	8.1	8.0	2.5	9.3	199.2	97.8	4237.0
EV8342-SR_N								
Babungo	59.7	9.6	10.7	2.2	11.0	160.3	75.7	4311.0
Jos_N								
Babungo	58.7	9.0	8.7	2.2	9.3	177.5	63.0	4607.3
Mean	59.8	9.4	10.0	2.2	10.5	178.7	85.6	4787.2
Grand Mean	58.6	18.8	22.8	3.4	10.8	174.0	80.3	4661.0
LSD(0.05)	2.4	7.6	11.2	1.7	2.2	26.9	15.7	1006.0

[a] - Area under disease progress curve (Cambell and Madden, 1990)
[b] - Percentage leaf area blighted
NB - All measurements in centimetres

TABLE II - PERCENTAGE GENETIC GAINS[a] CALCULATED FROM DISEASE AND AGRONOMIC INDICES FOLLOWING CONCENTRATING RESISTANCE TO NORTHERN LEAFBLIGHT INTO SUSCEPTIBLE CULTIVARS DURING THE SECOND RAINS OF 1992 AT KABANYOLO, UGANDA

	Days to 50% silking	AUDPC[a]	PLAA[b]	Lesion numbers	Lesion length	Flag height	Ear height	Yield (kg/ha)
KWCA-SR	-4.24	-78.04	-82.37	-79.24	25.25	3.40	13.22	30.36
EV8349-SR	-6.00	-72.99	-80.23	-57.63	13.89	17.18	44.73	43.92
EV8429-SR	0.49	-72.55	-72.08	-54.93	-17.54	2.61	10.76	38.56
Across	-3.40	-61.03	-70.43	-53.49	3.64	-4.71	-2.63	-3.59
Gusau	-1.21	-62.67	-67.08	-45.65	-13.89	14.81	24.59	-22.71
EV8342-SR	2.40	-12.73	9.32	0.00	-5.98	-9.69	0.26	-27.62
Ev Jos	-3.29	-70.30	-78.20	-55.10	-20.51	16.01	12.10	12.89
Means	-2.31	-61.47	-65.67	-57.67	-15.14	5.66	14.72	10.26

[a] - See Cambell and Madden (1981)
[b] - Area under disease progress curve (see Campbell and Madden (1990))
[c] - Percentage leaf area blighted
NB - All measurements in centimetres

TABLE III - VALUES OF CORRELATION COEFICIENTS FOR THE DIFFERENT DISEASE AND AGRONOMIC VARIABLES ASSESSED ON GENOTYPES AT KABANYOLO, UGANDA, DURING THE SECOND RAINS OF 1992

	Genotype	AUDPC[a]	PLAA[b]	Lesion numbers	Lesion length	Flag height	Ear height	Yield (kg/ha)
Genotype								
Day	-0.15							
AUDPC PLAA	-0.71	0.42						
PLAA	-0.70	0.43	1.00					
Lesion numbers	-0.68	0.23	0.96	0.96				
Lesion length	0.01	0.11	0.12	0.11	0.06			
Flag height	0.28	-0.17	-0.48	-0.51	-0.43	-0.15		
Ear height	0.31	-0.07	-0.45	-0.47	-0.43	0.05	0.83	
Yield	0.20	0.11	-0.59	-0.60	-0.52	0.28	0.32	0.28

NB - All measurements in centimetres

The negative genetic gains for 50% days to planting indicate reduction in maturity period, showing the effectiveness of the method in disassociating resistance from maturity (Ceballos *et al.*, 1991). This shows that breeding for resistance was effective in reducing plant height. This observation is of particular interest because the widely grown cultivar, KWCA-SR, has a very long maturation period, apart from being susceptible to NLB. The programme may thus end up increasing resistance and reducing the maturation period of the cultivars. The observation that yield increased with resistance contradicts earlier findings that breeding for resistance reduces the yield potential, but agrees with recent findings that breeding for resistance to NLB does not necessarily decrease yield potential, and that the potential depends on the disease level present (Ceballos *et al.*, 1991).

The study indicates that breeding for polygenic (rate-reducing) resistance to NLB using recurrent selection is effective in improving yield, especially under high disease pressure and in reducing plant height.

SUMMARY

A study was conducted at Kabanyolo, Uganda, to concentrate resistance to NLB to with a view to assessing the effect of increase in resistance on agronomic traits in maize. Seven locally grown maize cultivars were crossed with a resistant cultivar, Babungo 3, and the resulting F_1s grown together with the parents during the next season for evaluation. Genotypes were significant ($P \leq 0.05$) for all indices and replicates for all traits except days to 50% silking. F_1s performed well in almost all cases studied. Disease indices showed association with agronomic traits evaluated. Positive correlations were shown for days after planting while negative correlations were recorded between NLB and yield, NLB and flag height and NLB and ear height. For every 1% increase in resistance, there was a 11.75-kg/ha increase in yield. The study resulted in improvement of all traits evaluated except flag and ear heights.

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